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ABSTRACT

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College Major Similarity Profiles Based on Selected Washington Pre-College Measures and Vocational Interest Inventory Scores

Clifford E. Lunneborg and Patricia W. Lunneborg

Discriminant function analyses utilizing Washington Pre-College aptitude/achievement variables and Vocational Interest Inventory scores were performed to predict graduating major for June 1975 UW graduates (N=552) in eleven majors. Using both types of pre-college measures classified more graduates correctly than utilizing the cognitive or interest measures alone. Suggestions for improved feedback in the WPC program were made so as to provide future high school juniors with (1) 3 profile scores (based on the first three discriminant functions), (2) a graphic presentation called Plot of Aptitude and Interest Profiles for Typical College Graduates, and (3) a rank ordering of eleven college majors in terms of their closeness to the student's three profile scores.

Educational Assessment Center Project: 294

College Major Similarity Profiles Based on Selected Washington Pre-College Measures and Vocational Interest Inventory Scores

Clifford E. Lunneborg and Patricia W. Lunneborg

Problem

Beginning with high school (HS) juniors tested in 1970 all participants in the Washington Pre-College (WPC) Testing Program who indicate that they intend to obtain at least a bachelor's degree receive as part of their Guidance Report a "College Area Similarity Profile." These profiles are based on a discriminant function analysis of the HS grades and WPC aptitude/achievement test scores for 1392 University of Washington (UW) students who graduated in June 1969 in six major areas--humanities, physical science, social science, business, biological science, and engineering (Lunneborg & Lunneborg, 1970). At the time similarity reporting was introduced, the expectation was that these profiles would be sharpened when it became possible to add test scores from the Vocational Interest Inventory or VII (Lunneborg, 1975b) to the discriminant functions. It is well known that occupational choice or choice of college major is less well discriminated on the basis of cognitive tests than on the basis of interest tests (Stahmann, 1969). Thus, it was expected that the limited discriminability based on the WPC data alone would be significantly enhanced later.

The first sizable group of students to enter UW who had VII data graduated in June 1975 (having been tested as HS juniors spring 1970). While the various major groupings among them will have to have added to them June 1976 graduates (many of the samples are small), it was important to conduct the earliest possible analysis of the contribution of interests to this very important area of decision-making--What to major in?

A second motivation for the present study was to overcome some of the problems associated with interpreting similarity profiles of the kind presented by WPC. The Student Guide (Washington Pre-College Testing Program, 1975) explains the Guidance Report feedback which consists of both a ranking of each of the six broad areas and a verbal designation

for each of high, moderate, slight, or very slight similarity. Both types of feedback are based upon the closeness of a student's two discriminant function scores to the average discriminant function scores earned by graduates in each of the six groups. The discriminant function scores earned by the graduates in any one of the groups are distributed about this average and a student's similarity to the group depends upon where that student's score is located in that distribution. If the student is so far away that, indeed, more than 75% of the graduates are closer to the average, then the student bears only "very slight"similarity to that major group. If 50-75% of graduates are closer to the average, the student is "slightly" similar; if 25-50% are closer, the student is "moderately" similar; and, lastly, if fewer than 25% of graduates are closer, the student is designated as having "high" similarity to graduates of that area.

Although reporting these verbal descriptions is in accord with earlier recommendations (Lunneborg & Lunneborg, 1970), the very special nature of discriminant function scores is lost sight of, resulting in considerable misinterpretation. Discriminant functions are derived not to typify any group, but to account for differences between groups. Thus, discriminant function scores cannot be used to say whether a student is similar to a group or not, but rather to say whether a student is more similar to one group than to another. For example, it is quite possible for a promising university entrant to be presently labeled as only very slightly similar to all of the six areas. This sometimes is interpreted as meaning that the student is not like any of the groups. It should be interpreted instead as meaning that the student is not more like one of the groups than the others. This student is equally like all groups rather than unlike all groups. While the practice of reporting rankings does reflect the notion of relative closeness to major groups, it fails to suggest where differences in rank correspond to substantial differences in closeness and also can be a source of misinterpretation. Thus, the feedback of discriminant function results represents an equally important aspect of the "similarity profile" to be improved.

Method

Subjects. Of the 3,000 first year students entering UW autumn 1971 who had taken the WPC battery spring 1970, 1633 were registered three years later, spring 1974, and had 90 or more credit hours (junior standing). This sample contained 45% females and had a mean age at time of testing of 16.5. By spring 1975 graduation had been achieved by 809 students and it is these graduates who were studied here.

Majors. Of the 809 who graduated, however, only 552 participated in the discriminant function analyses. Eliminated were students in areas with fewer than 25 graduates. The final set of eleven majors with Ns in parentheses were: biological sciences (66), engineering (54), fisheries/forestry (30), health professions (44), humanities (59), arts (30), political science (26), physical sciences (51), business administration (116), communications (37), and nursing (39). Earlier analyses resulted in the exclusion of psychology and social welfare as majors, and of the broad area of social science, because these three groups could not be well differentiated from the others. Not included, too, were students from the College of Education because of their great diversity.

Predictors. To reduce redundancy not all of the WPC variables (7 GPA's, 7 verbal scores, 6 quantitative scores, spatial ability and mechanical reasoning) were utilized. Based on their correlations with both academic and nonacademic four-year criteria of college performance (Lunneborg, 1975a), the following seven WPC predictors were selected for discriminant function analysis: overall HS GPA, Vocabulary (VO), English Usage (EU), Quantitative Skills Total (QS), Mathematics Achievement (MA), Spatial Ability (SA), and Mechanical Reasoning (MR). The VII contributed another eight predictors, scores in Service (SER), Business Contact (BUS), Organization (ORG), Technical (TEC), Outdoor (OUT), Science (SCI), General Cultural (CUL), and Arts and Entertainment (ART).

Analyses. Three separate discriminant function analyses were conducted to differentiate the eleven major groups: using WPC variables alone, VII scores alone, and WPC and VII variables together.

Results

Table 1 presents the means with standard deviations in parentheses of the fifteen predictors for the eleven majors. The highlights for each group can be summarized as follows: Biological Science majors were high on HS GPA, Quantitative Skills, Mathematics Achievement, and SCI. The outstanding scores for Engineering majors were MR, QS, and TEC interest. Like the two previous groups, Fisheries/Forestry majors were high in Quantitative Skills, and unlike all other groups, their Outdoor interest was very elevated. The Health professions were characterized by high HS GPA and SCI interest but contrast with Physical Science Majors who were higher on all WPC variables and in SCI interest, but whose SER interests were very low. The humanities majors were high in Vocabulary and low in Spatial Ability and, not surprisingly, their highest VII area was CUL. Arts majors had high ART and low TEC interests, while Political Science graduates had the lowest HS GPA, Mathematics Achievement and Spatial Ability scores. Political Science graduates also had the highest interest in Business Contact and the lowest interest in Science. Business Administration majors did better on the Quantitative Skills test than the other WPC variables, and were characterized by high ORG and low OUT interests. Communications graduates were very similar to Political Science graduates although they had even lower OUT interest. Nursing graduates, finally, were low on Quantitative Skills and Mechanical Reasoning compared to the other groups, at the same time having the highest SER scores and were low in TEC interest.

The discriminant function analysis in which WPC variables alone were utilized resulted in three significant functions, accounting in turn for 65%, 19%, and 8% of between group variability. The first function was roughly typified as a quantitative vs. verbal dimension with engineers and physical scientists at one end, and humanities, arts, and nursing majors at the other end. The second function is harder to describe, but it discriminated most sharply nursing and health professions (perhaps because of high HS GPAs) from political science (high Vocabulary) and engineering (high Mechanical Reasoning) majors. These three discriminant functions "correctly classified" 27% of the 552 graduates, i.e., their discriminant function scores were closer to the average of their group

Table 1

Means (and Standard Deviations) of WPC and VII Variables for Eleven Graduating Majors (June 75)

		Variables													
Major	HS GPA	VO	EU	QS	MA	SA	MR	SER	BUS	ORG	TEC	OUT	SCI	CUL	ART
BIO SCI	3.5(.3)	57(8)	54(6)	63(7)	57(5)	53(8)	53(10)	48(10)	44(10)	46(9)	51(8)	50(10)	61(9)	51(9)	48(11)
ENGR	3.4(.3)	56(8)	53(6)	66(8)	59(4)	57(8)	65(9)	42(8)	48(10)	54(9)	59(7)	44(10)	57(9)	50(11)	46(7)
FISH/FOR	3.3(.3)	54(6)	52(6)	61(7)	56(5)	51(8)	53(10)	44(10)	47(10)	46(10)	51(9)	58(10)	57(10)	48(9)	48(10)
HEALTH	3.5(.4)	54(8)	52(7)	60(8)	54(5)	52(9)	50(9)	50(8)	47(11)	50(8)	50(7)	48(10)	60(10)	47(8)	48(10)
HUM	3.3(.4)	58(10)	55(8)	55(10)	52(6)	47(9)	47(8)	50(10)	48(11)	49(8)	46(8)	51(9)	50(10)	56(10)	52(11)
ARTS	3.3(.3)	57(8)	55(6)	56(9)	52(6)	49(10)	47(10)	49(8)	46(10)	49(12)	46(9)	50(10)	50(11)	51(8)	61(9)
POL SCI	3.2(.4)	56(8)	52(7)	55(8)	51(5)	46(9)	51(10)	48(8)	56(11)	50(10)	48(8)	47(10)	47(10)	57(10)	49(9)
PHY SCI	3.6(.3)	58(9)	55(8)	69(8)	61(4)	55(8)	59(9)	44(8)	46(11)	50(12)	54(8)	48(12)	61(9)	51(10)	45(9)
BUS ADM	3.4(.5)	52(9)	51(7)	61(9)	56(5)	50(9)	51(10)	47(9)	53(11)	57(11)	51(8)	44(10)	49(10)	53(10)	47(10)
COMM	3.3(.3)	56(8)	53(7)	56(9)	53(6)	47(9)	48(10)	48(9)	55(11)	50(7)	47(9)	43(9)	49(10)	58(13)	52(10)
NURSING	3.5(.3)	54(8)	53(8)	56(10)	52(6)	50(9)	43(6)	55(7)	44(10)	51(9)	46(7)	49(9)	58(8)	51(10)	48(9)

than to the average for any other group. While this seems like a small number, it should be contrasted with assignment at random which would be 1 out of 11 or 9%. For the individual groups accuracy of classification ranged from 5% for Communications and 7% for Arts to 54% for Nursing and 59% for Engineering. The average of these individual group percentages was 26%.

When the VII scores alone were the predictors, five significant functions resulted. They accounted in turn for 41%, 40%, 13%, 7%, and 6% of between group variability. The first contrasted SCI and TEC scores with CUL and ART, placing Engineering and Physical Science furthest away from Arts and Humanities. The second discriminant function gave negative weight to TEC and ORG, and positive weight to SCI and SER. The majors most separated here were Engineering and Business from Nursing and Health Professions. The number of correctly classified majors in this analysis was better than using WPC variables alone, 30%. For individual groups accuracy ranged from 12% for Physical Science to 60% for Arts; the average over all groups was 32%.

Combining WPC and VII predictors resulted in five significant functions, accounting for 45%, 24%, 13%, 6%, and 5% of between group variability respectively. The first three functions accounted for the bulk of this variability and the standard and raw weights associated with each are given in Table 2. The raw weights can be used to compute discriminant function scores for new cases and form the basis for modifying the present WPC similarity profiles. Because of differences in scales used for the several predictors, raw weights are not easily interpreted. In contrast, the standard weights, also given in Table 2, are the weights which would be appropriate if all predictors had the same means and variance. Even these weights, however, make description of the discriminant functions difficult in that the magnitudes and even the algebraic signs of them are a function of the interrelations among the predictors. Consider the standard weights for MR, SER, and TEC on the first discriminant function. One would be inclined to interpret the weight of .90 for SER as signifying that its contribution to the discriminant function was intermediate to that of .41 for MR and 1.40 for TEC and in the same direction. Since SER is negatively related to both MR and TEC, however, any

Table 2

Standard and Raw Weights for First Three Discriminant Functions

Using WPC and VII Variables to Predict Graduating Majors

Variable	Functions					
	Standard weights			Raw weights		
	1	2	3	1	2	3
HS GPA	.07	.33	-.37	.18100	.84477	-.94860
VO	-.01	.15	.40	-.00119	.01696	.04579
EU	-.28	-.07	.16	-.04030	-.01009	.02247
QS	.21	.16	-.32	.02221	.01682	-.03399
MA	.32	-.23	.20	.05374	-.03789	.03392
SA	.14	.18	-.19	.01486	.01953	-.02063
MR	.41	-.42	.41	.03770	-.03868	.03764
SER	.90	.38	.36	.09658	.04042	.03805
BUS	1.21	-.05	.88	.10852	-.00477	.07926
ORG	1.21	.00	.40	.11612	.00037	.03882
TEC	1.40	-.02	.78	.15983	-.00250	.08880
OUT	1.23	.26	1.25	.11789	.02486	.11969
SCI	1.61	.80	1.00	.14688	.07318	.09157
CUL	.94	-.19	.91	.09252	-.01853	.08895
ART	.90	.20	1.11	.08974	.02030	.11059
Additive constant				-52.07470	-7.95215	-34.01080

interpretation based on this reading of the standard weights would likely be erroneous. If one keeps in mind that discriminant functions are essentially factors, their interpretation is more nearly correct if the same strategy is adopted for them as for the results of a factor analysis. Factors are commonly described in terms of their correlations with the original variables. Table 3 gives the correlations of each of the three discriminant functions with the WPC and VII variables.

The first discriminant function, then, seems interpretable as a technical-quantitative dimension. The second discriminant function is close to the SCI vs. BUS dimension found repeatedly in the VII (Lunneborg, 1975b). The third discriminant function with positive loadings on VO, OUT, and, to a lesser degree, MR and ART, and with negative loadings on ORG, SER, and BUS, is not easily typified.

The average scores for the major groups on each of the discriminant functions are given in Table 4 and the first two are depicted in Figure 1. Looking at Figure 1, on the one end of the first function are physical scientists and engineers, at the other end arts and humanities majors. At the one end of the second function are political science and business, and at the other end nursing and health professions. The third function gives low scores to business and nursing and high scores to fisheries/forestry and arts suggesting that the third dimension is somewhat related to the VII factor, ORG vs. OUT. Table 4 is to be used with the raw weights in Table 2 to develop similarity profiles for individual students taking the WPC battery.

The combined set of VII and WPC variables correctly classified 36% of the cases. The accuracy for individual groups ranged from 15% for humanities to 67% for engineering; the average over all groups was 37%. Table 5 illustrates the predicted group membership for members of the eleven major groups. Proceeding from Group 1 down, the major misclassification for BIO SCI was in the placing of 11 graduates in PHY SCI. For both ENGR and FISH/FOR there were no major problems of misclassification. For HEALTH, however, nearly as many graduates were placed in NURSING as in the correct classification. Taken together, the misclassifications for both BIO SCI and HEALTH are logical and consistent and present no major

Table 3

Correlations of First Three Discriminant Functions with WPC and VII Variables

Variable	Discriminant Functions		
	First	Second	Third
HS GPA	25	32	-12
VO	06	08	45
EU	00	08	27
QS	67	00	05
MA	69	-06	09
SA	51	10	04
MR	74	-27	36
SER	-40	32	-34
BUS	-17	-55	-23
ORG	08	-42	-56
TEC	62	-18	12
OUT	-06	36	42
SCI	51	68	14
CUL	-26	-35	04
ART	-36	06	34

Note. Decimal points omitted. Underlined are correlations greater than |.40|. Correlations based on 809 graduating seniors.

Table 4

Average Discriminant Function Scores for Eleven Major Groups

Group	Function First	Second	Third
BIO SCI	.36473	.68724	.24565
ENGR	1.46744	-.61469	.19534
FISH/FOR	.24086	.20677	.68423
HEALTH	.16300	.87501	-.37961
HUM	-1.11187	-.06854	.38683
ARTS	-1.19212	.16185	.55720
POL SCI	-.86544	-.83491	.38618
PHY SCI	1.27759	.23833	.24522
BUS ADM	-.01445	-.59361	-.61124
COMM	-.85275	-.57448	.14210
NURSING	-.66088	1.07661	-.69294

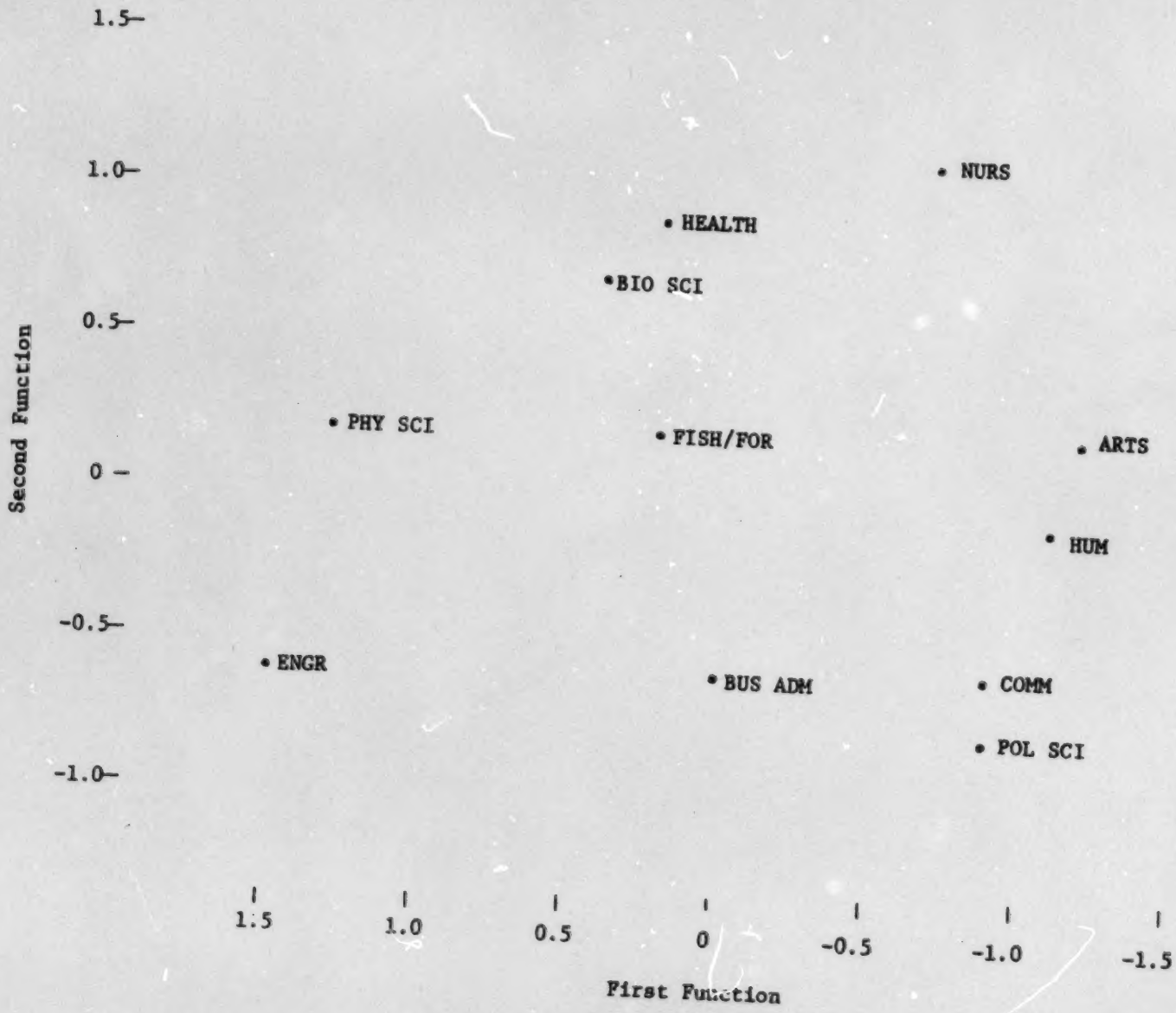


Figure 1. Centroids for eleven majors on the first two discriminant functions, VII and WPC analysis.

Table 5

Frequencies for Predicted Major Groups Based on Three Discriminant Functions

Actual group		Predicted group 1	2	3	4	5	6	7	8	9	10	11	N
1	BIO SCI	16	7	5	8	4	9	1	11	1	0	4	66
2	ENGR	0	36	3	2	0	1	1	6	5	0	0	54
3	FISH/FOR	0	3	13	1	0	4	2	3	3	0	1	30
4	HEALTH	2	2	3	12	0	3	2	5	3	1	11	44
5	HUM	1	3	7	2	9	13	7	0	4	6	7	59
6	ARTS	3	2	2	1	2	13	4	0	0	0	3	30
7	POL SCI	0	0	2	0	1	5	11	1	1	5	0	26
8	PHY SCI	3	11	9	5	0	0	1	16	4	0	2	51
9	BUS ADM	2	16	9	8	2	8	8	4	43	10	6	116
10	COMM	2	2	4	0	5	3	9	1	2	8	1	37
11	NURSING	4	0	2	4	2	2	0	0	0	3	22	39

Note. Based on 552 June 1975 UW graduating seniors using WPC and VII variables in calculating the discriminant functions. Underlined are the "correct" classifications.

problem in guidance practice. Group 5, HUM, on the other hand, had more graduates placed in ARTS, which, while a "sensible" misclassification, nonetheless, represents a primary area for future improvement.

While HUM majors were misclassified as ARTS, the reverse was not true and ARTS graduates, as those in POL SCI, were not subject to systematic misclassification. An appreciable number of PHY SCI graduates were understandably misclassified as ENGR. The greatest number of misclassifications for BUS ADM was also in ENGR, not as comprehensible, but based on the shared organizational interests of the two groups. COMM graduates were more likely classified as POL SCI, which like the problem with HUM graduates is a "sensible" misclassification, at the same time that it is an important area for future research. Table 1 illustrates the likeness of COMM and POL SCI; their profiles of abilities and interests are almost identical. The last group in Table 5, NURSING, represented no major problem in classification.

Discussion

As a final check before implementing these results, the discriminant functions developed here will be cross-validated against the majors of students who entered the University a year later, autumn 1972, as listed by the Registrar autumn 1975 (the start of their "senior" year). (Still later, when these 1972 entrants graduate the discriminant functions can be redone so that they are based on larger groups of graduates.) In the meantime, however, the results presented here can be used, starting with HS juniors tested spring 1976, to replace the current WPC similarity profile. To do so requires that the raw weights of Table 2 be multiplied by WPC and VII scores to define three discriminant function scores for each individual. These discriminant function scores are in turn used to calculate eleven chi-squares, one for each major group. A typical chi-square is computed by finding the sum of squares of the differences between an individual's discriminant function scores and the average scores for a particular group. These averages or centroids are given in Table 4.

An illustrative example is the following 16-year-old female tested in 1975 with the following scores on the 15 variables listed in Table 2: HS GPA, 3.95; VO, 71; EU, 66; QS, 61; MA, 57; SA, 40; MR, 39; SER, 57;

BUS, 34; ORG, 43; TEC, 39; OUT, 40; SCI, 50; CUL, 81; ART, 61. (She indicated a planned major in education with postgraduate work but no degree.) To calculate the discriminant functions using Table 2, DF 1 = (3.95 x .18100) + (71 x -.00119) + ... + (61 x .08974) + (-52.07470) = -2.17222. DF 2 = (3.95 x .84477) + (71 x .01696) + ... + (61 x .02030) + (-7.95215) = 0.51282; DF 3 = (3.95 x -.94860) + (71 x .04579) + ... + (61 x .11059) + (-34.01080) = .79232. Then, the chi-squares for each of the groups from Table 4 are calculated as follows: BIO SCI = $[.36473 - (-2.17222)]^2 + [.68724 - (.51282)]^2 + [.24565 - (.79232)]^2 = 6.765$. This student's chi-square values ordered from smallest to largest were:

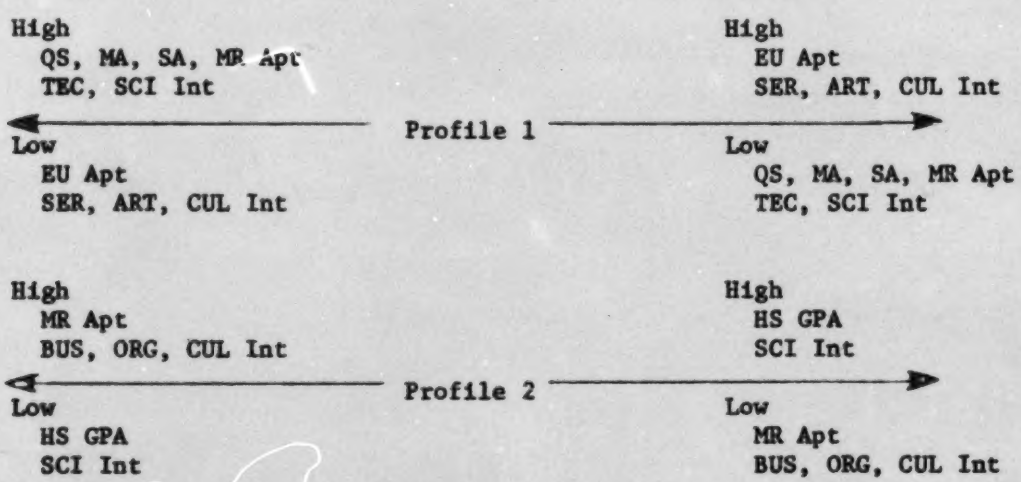
ARTS	1.139
HUM	1.627
COMM	3.346
POL SCI	3.689
NURSING	4.808
FISH/FOR	5.928
BUS ADM	6.508
BIO SCI	6.765
HEALTH	6.958
PHY SCI	12.276
ENGR	14.875

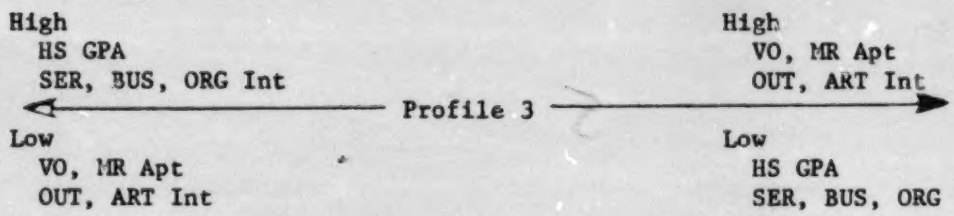
How can these data best be presented so that this student is led to see where she is in the space which discriminates among successful graduates in the different majors? Because the use of scores for the majors, whether chi-square values or centour scores or indeed even verbal score descriptions, leads to assigning low "similarity" scores to all students who depart from the average group performance for a given major (regardless of whether that departure reflects greater or lesser ability and/or interest than the average person in that major), such scores cannot avoid being misunderstood. As an example, looking at the standard weights in Table 2, a student with very high MR and SCI scores could obtain discriminant function scores so far removed from the average scores for the ENGR group that the student would be typified as dissimilar to ENGR (in addition to all the other groups). In fact, this student exceeds engineering

graduates in the very aptitudes and interests that differentiate engineers from other graduates.

These problems can hopefully be overcome by a graphic presentation supplemented by a report of the ordering of computed chi-squares. The first aspect to the graphic illustration is contained in Figure 2 and the student whose chi-squares were reported is used here as an example. Plotted in Figure 2 is her position in two-dimensional space based on her first two discriminant functions called here "profile scores." Additional information to be gained from her third profile score (.79) is provided in Figure 3 through a 1-dimensional array of the major groups in terms of their average scores on the third discriminant function. Students should be advised that the first two "profile scores" will probably provide the most important guidance information re: majors to be considered, but that should they be equally close to two or more majors, the content of Figure 3 may be helpful. For example, a student with DF 1 = -.5 and DF 2 = -.7 is close to BUS ADM, COMM, and POL SCI, and Figure 3 would facilitate the discrimination of BUS ADM from the other two majors. Notice that in Figures 2 and 3 it is suggested that the profile scores, ranging in the normative population about zero, be reported in WPC standard score form, ranging about 50.

Notice that the three profiles are elaborated by brief verbal descriptions at their extremes based on the correlations of Table 3, with Apt indicating aptitude, Int indicating interest. The descriptions are:





The graphic presentation summarized in Figures 2 and 3 for the student example would be accompanied by a list of the eleven majors ordered by the increasing magnitude of the computed chi-squares. Thus, the student example is most like ART and HUM graduates and least like PHY SCI and ENGR in terms of the aptitude and interest measures that discriminate between these groups.

The elements in the feedback system thus include three "profile scores" in WPC standard form, a graphic presentation on which students plot these three profile scores called Plot of Aptitude and Interest Profiles for Typical College Graduates, and a rank ordering of the eleven college majors which could be labeled List of Majors Ranked by Closeness to Your Profile Scores.

Perhaps the best way then to direct students to use this feedback is to have them begin by plotting their first two profile scores. Second, the ordering of the eleven majors should be consulted and the student asked to think about the match between the place he/she occupies on the plot and the way the majors have been ordered. In the present example, the student would find that she is both closest to ARTS and HUM on the plot and that these two majors are at the top of her list. However, when the plot and list do not agree, then students should plot their third profile score. (In general, the third profile will not be valuable to students whose plots on the first two profiles place them outside the cluster of group averages.)

The profile scores with student hand-plotting is only one of several ways the data could be returned. It would be possible to have the plots automatically prepared as part of the Guidance Report. A decision here may rest on whether it is considered desirable to provide profile information for all WPC participants or only those who indicate they intend a bachelor's degree.

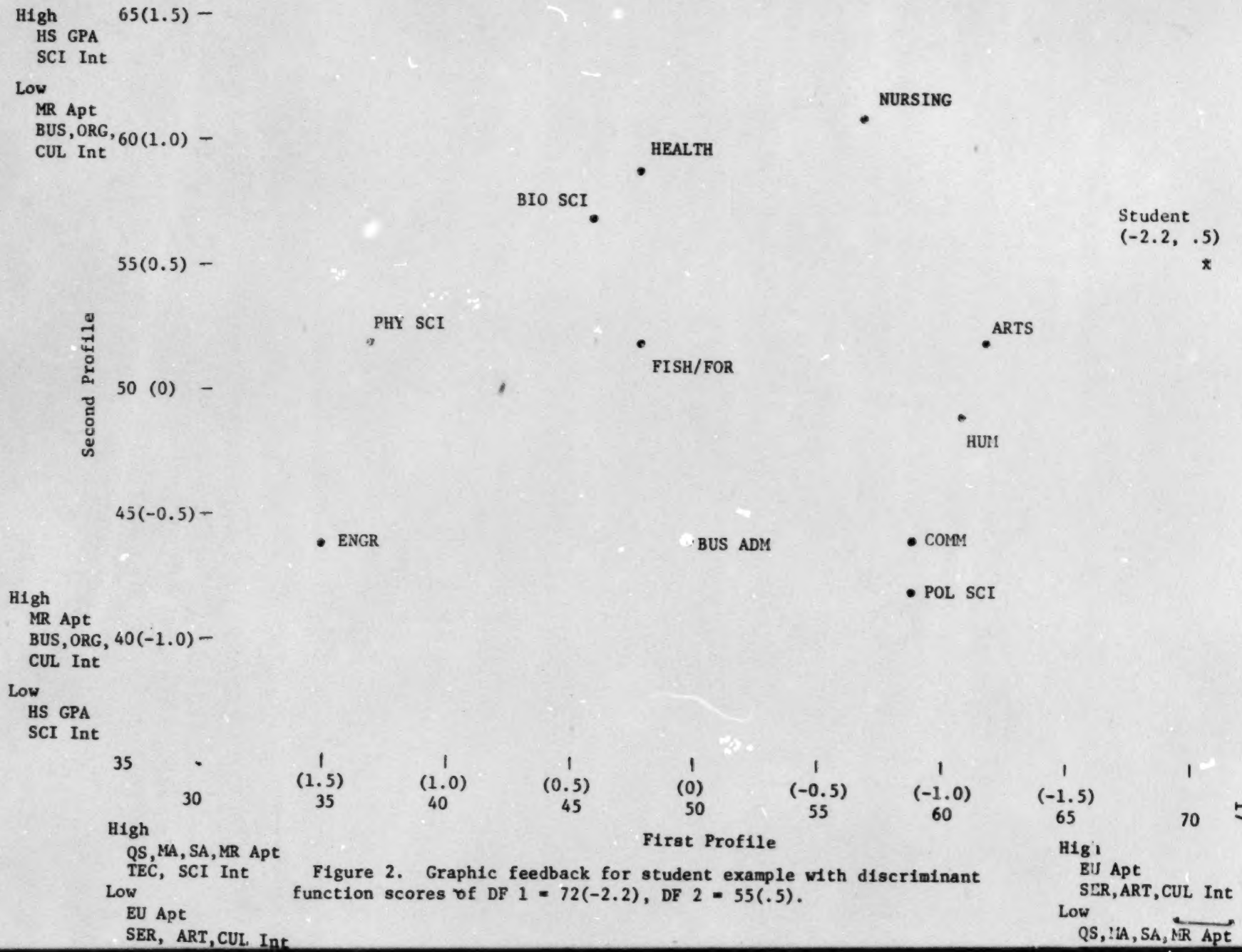


Figure 2. Graphic feedback for student example with discriminant function scores of DF 1 = 72(-2.2), DF 2 = 55(.5).

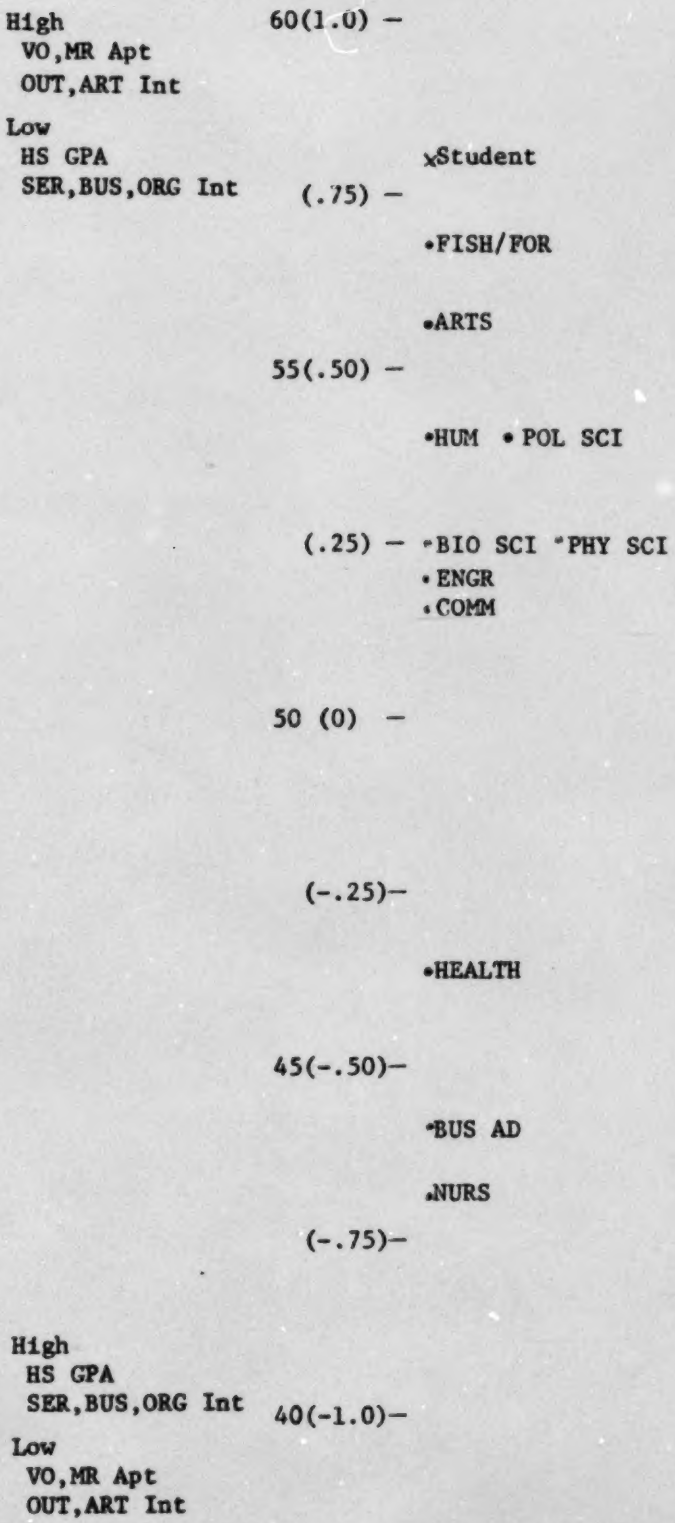


Figure 3. Graphic feedback for student example with DF 3 = 58 (.79).

These recommendations on the presentation of discriminant function results borrow heavily on the excellent report by Dale Prediger (1971) describing a similar computer-based system for converting test data into useful counseling information for deciding among different educational programs.

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